Test method for determining the acoustic performance of noise reducing devices installed on the top of highway noise barriers

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ABSTRACT

After the report about edge potential concept of a noise barrier by Fujiwara, various types of noise reducing device(NRD) called “Noise reducer” have been suggested for getting more shielding efficiency on the top of highway noise barriers. But, it has been doubtful of the exact effect by the NRD’s itself because there was no appropriate and unified method to determine the acoustic performance of the NRD’s in Korea, and because of this the NRD’s could not applied in proper way for the highway traffic noise abatement.

In this study, the authors have considered to set-up a reasonable and practical method to estimate the noise shielding efficiency of NRD’s in the outdoor conditions. For this, the measuring range of receiving area was considered to 40 meters behind the barrier and 6 meters above the top edge of the barrier. The weighting frequency spectrum and range was considered for the actual application to the highway noise. And to eliminate the noise shielding effect of the NRD’s height itself, the source and measuring points were adjusted as high as the NRD’s heigth. For the frequency weighting in the estimation of the NRD’s, highway noise spectra were measured at asphalt and concrete road side in Korea and then averaged for a unit spectral parameter. Lastly, to estimate the acoustic performance of a NRD as the equivalent height of a plain straight noise barrier, the noise shielding effect was calculated by the KHTN(the Korea Highway Traffic Noise prediction program).

1. INTRODUCTION

Installing of noise barriers has been the most common method for abating the highway traffic noise to the road side residential area, and after the report about edge potential concept of a noise barrier by Fujiwara[1], various types of noise reducing device(NRD) called “Noise reducer” have been suggested for getting more shielding efficiency on the top of highway noise barriers. But, it has been doubtful of the exact acoustic performance by the NRD’s itself because there was no appropriate and unified

method to determine the acoustic performance of the NRD's in Korea, and because of this the NRD's could not be applied in proper way for the highway traffic noise abatement. In this study, largely three main concepts were considered to set-up a reasonable and practical method to estimate the noise shielding efficiency of NRD's, receiving area, weighting spectrum and estimating frequency range in the outdoor conditions. For this, the measuring range of receiving area was considered to 40m behind the barrier and 6m above the top edge of the barrier. The weighting frequency spectrum and range was considered for the actual application to the highway noise. And to eliminate the noise shielding effect of the NRD's height itself, the source and measuring points were adjusted as high as the NRD's heigth. For the frequency weighting in the estimation of the NRD's, highway noise spectra were measured at asphalt and concrete road side in Korea and then averaged for a unit spectral parameter. Lastly, to estimate the acoustic performance of a NRD as the equivalent height of a plain straight noise barrier, the noise shielding effect was calculated by the KHTN(the Korea Highway Traffic Noise prediction program).

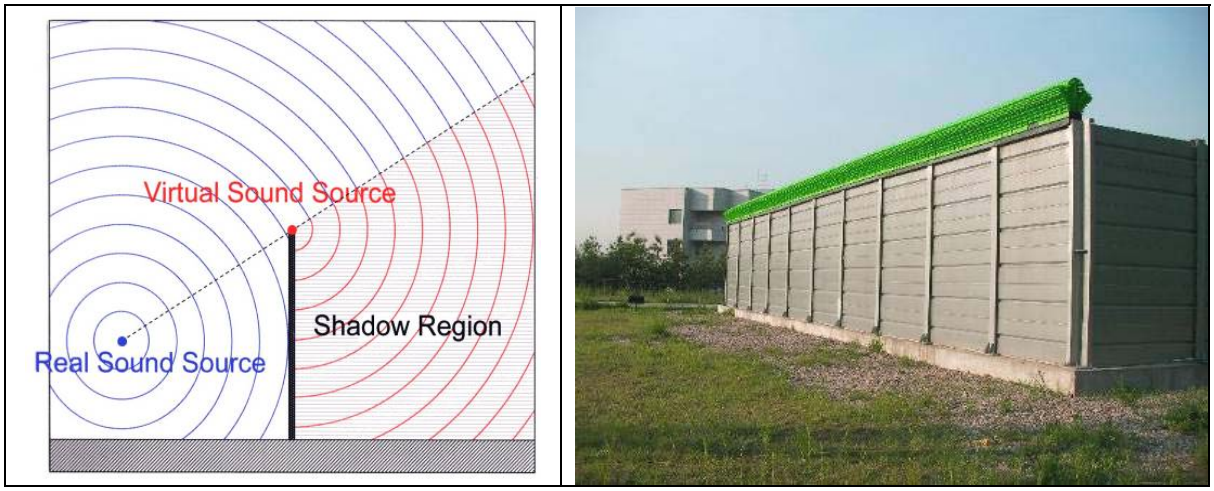


Figure 1. Main idea of the NRD and test setting on the noise barrier for acoustic test

Figure 2. Various types of NRD's suggested in Korea for commercial use

2. CONVENTIONAL TEST METHODS

For the acoustic performance test of NRD's, a conventional method has been mainly used shown in Figure 3. which suggested in Japan. This method has been generally used for the test of noise barriers and NRD's but, the measuring points are so closed to the barrier that the results seem hard to represent the NRD's acoustic performance in the practical use. In this method, the acoustic performance would be shown by the difference of sound pressure level between the after and before mounting the NRD's on the top of a noise barrier, so if the height of a NRD taller than the other the acoustic performance would be better. This method was suggested for testing the acoustic performance of noise barriers but, now generally used for testing the NRD's also. The acoustic performance of NRD's estimated by arithmetic average of decreasing amount of noise at each receiver. This method is not official but traditionally used for testing the acoustic performance of NRD's in Japan.

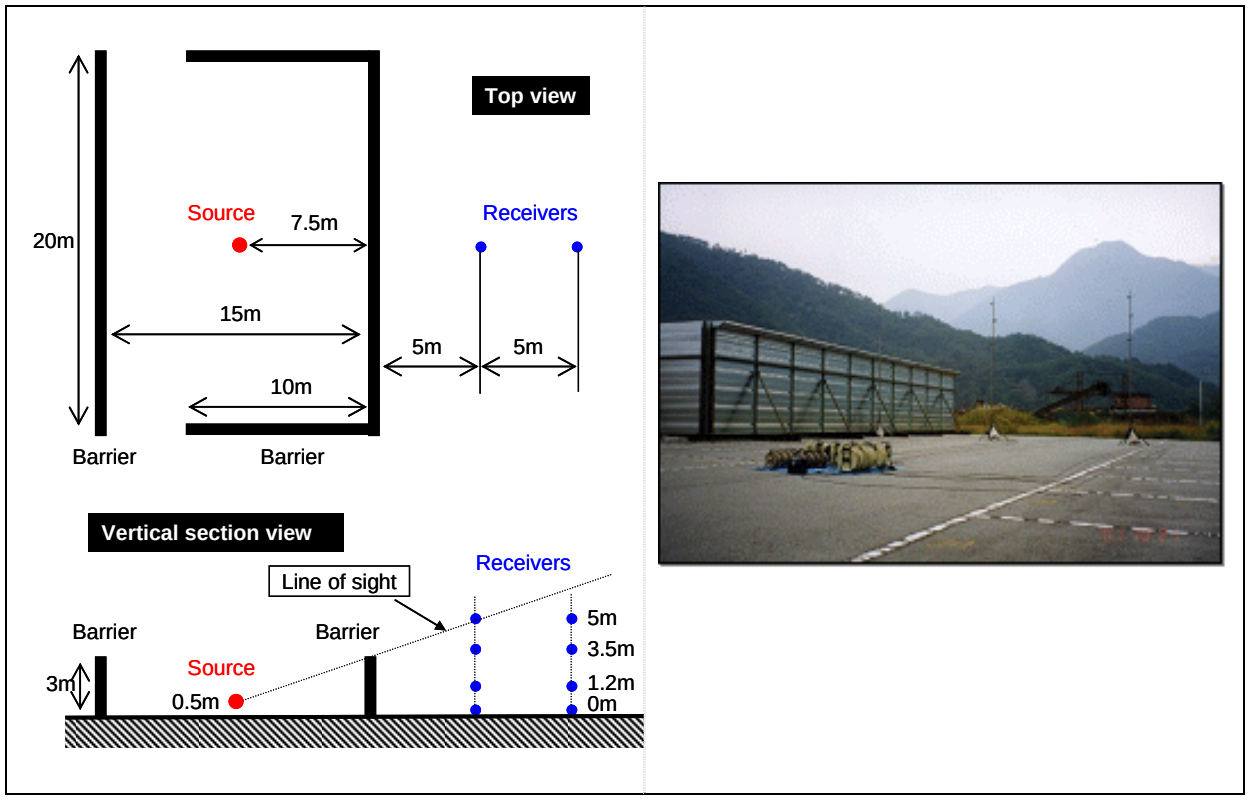


Figure 3. Measuring feature of Japanese conventional test method

Figure 4 shows the European test method of NRD's using impulse noise source. Because of using an impulsive sound source, it could be eliminated the influences of reflected sounds by ground and any other objects around the test area. Because of the position of the noise source and receivers are measured from the top of a barrier in both cases with and without a NRD, The height effect of a NRD itself, but the measuring points are also seemed closed to the barrier, it seems difficult to estimate as real situation. This method is refered in CEN/TS 1793-4 and not be adopted as a standard yet.

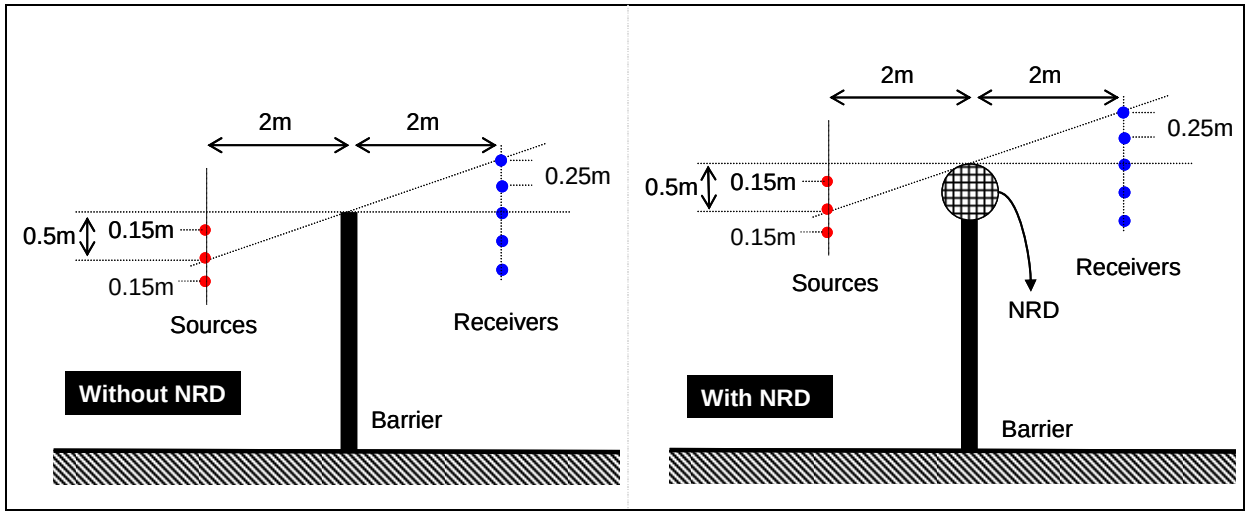


Figure 4. Measuring feature in CEN/TS 1793-4 for testing of NRD's

The noise source is placed in front of a NRD and the receivers placed on the other side of the NRD both the transmitted sound pressure wave traveling from the sound source through the NRD and the sound pressure wave diffracted by the top edge of the NRD under test. If the measurement is repeated without anything between the source and the receiver, the direct free-field wave can be acquired. The power spectra of the direct and the top-edge diffracted components, corrected to take into account the path length difference of the two components, give the basis for calculating the diffraction index. The measurement procedure and diffraction index calculation shall be carried out twice: one with, and one without NRD. The diffraction index difference would be then calculated: this is regarded as a relevant characteristic of the added device under test.

3. CONSIDERING A PRACTICAL METHOD

For considering a practical test method to estimate the acoustic performance of NRD's, measuring area was considered firstly. Figure 5 shows the measuring feature for considering. As a whole, the concept of evaluating method is similar to the Japanese conventional method except for positioning manner of noise source and receivers. The source and receivers are set from top-side of a barrier which like the same manner in CEN/TS 1793-4 for the purpose of excluding the height effect of NRD's itself. The noise signal used in the considering method is random noise which like Japanese conventional method. In order to check the noise source from the loudspeaker, set a monitoring microphone 1.5 meters above the top of barrier. Let the receivers set from 10 to 40 meters behind the barrier, 3 meters below and 6 meters above the reference position level which located on the top of a barrier or a NRD when it installed. Figure 6 shows photos of test site and facilities for this study. The ground condition of source side is reflective-like with gravel covering and receiver side is absorptive-like with grass covering.

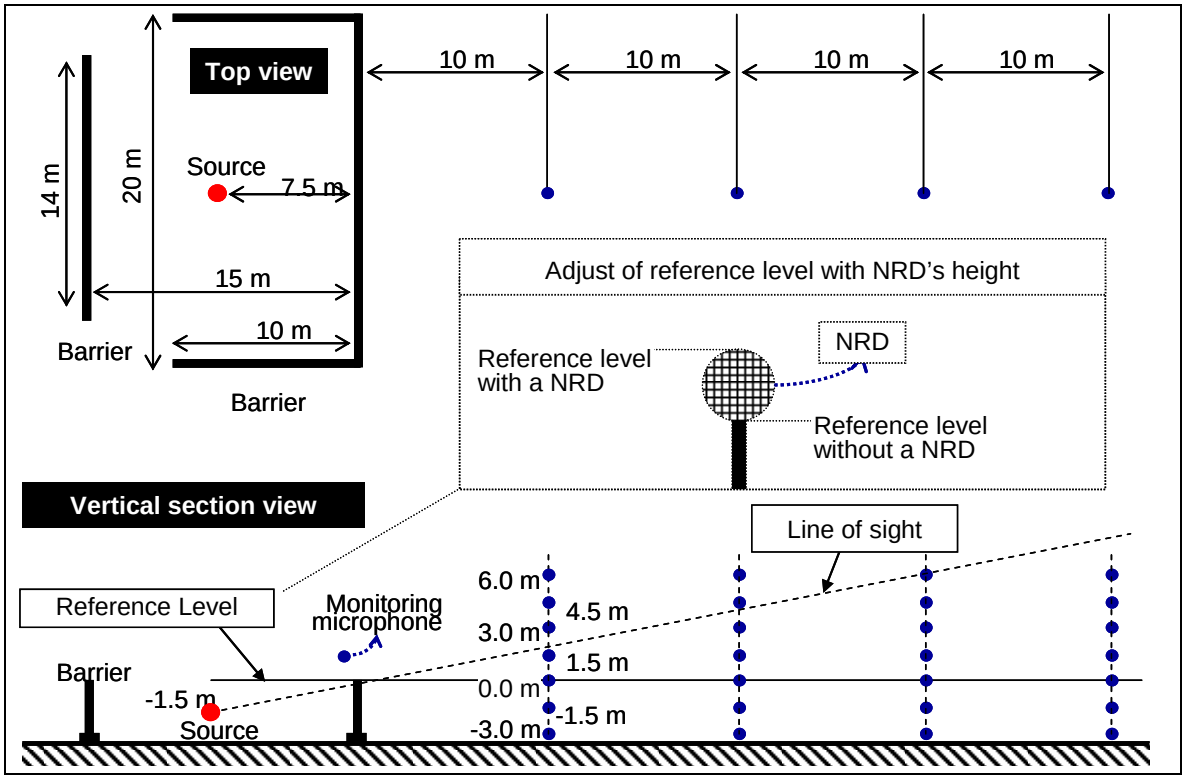
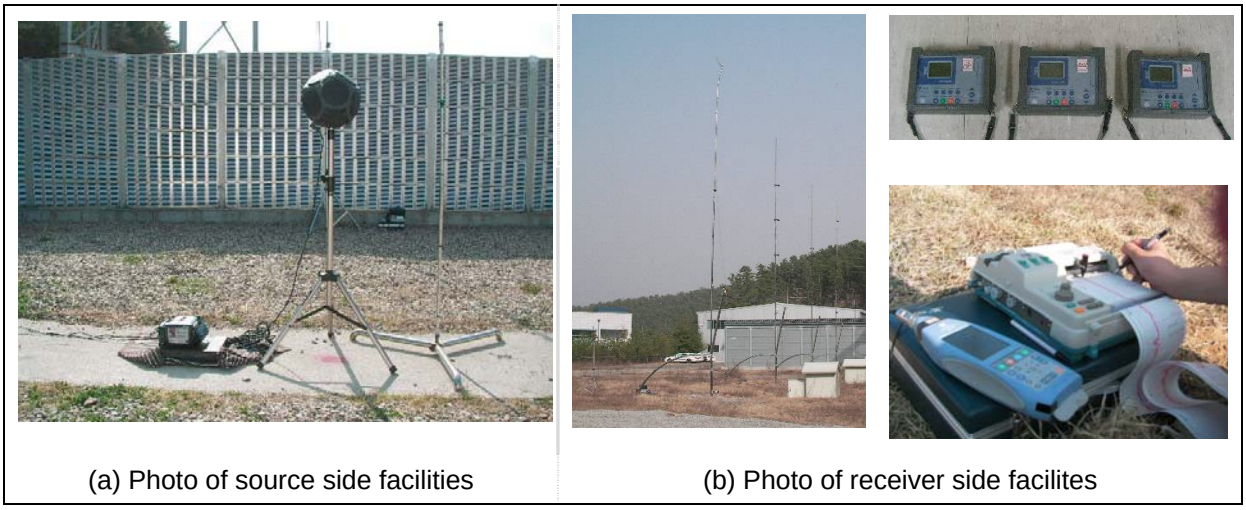


Figure 5. Measuring feature for considering a practical method



(a) Photo of source side facilities (b) Photo of receiver side facilites

Figure 6. Photos of test site and facilities for the study

For estimating the acoustic performance of NRD's, Korean highway noise spectrum was considered. This spectrum was recorded from Korean highway over 20 sites and then averaged for one spectrum. Figure 7 shows the highway noise spectrum considered on the study and A-weighting spectrum respectively. As shown in the figure of highway spectrum, 1kHz is the most effective than other frequencies of A-weighting spectrum. In order to reduce the highway noise effectively by the NRD's, near the 1kHz of frequency may be targeted. By a report about road traffic noise[2], the energies of road traffic noise are concentrated in certain frequency range. Figure 8 shows the noise

energy distributions with the frequencies of calculated by ASJ(Acoustic Society of Japan) model, road traffic noise prediction model of NIER(National Institute of Environmental Research), Korea, and measured spectrum. As shown in the figure, more than 90% of noise energies are concentrated in 250- 4kHz of octave band center frequency range. In accordance with the results, it will be sufficient that the estimating frequency range may be 250Hz to 4kHz (200Hz to 5kHz in 1/3 octave band center frequency). By excluding the data of low and high frequency ranges, the results of estimation would be stable and confidential hopefully.

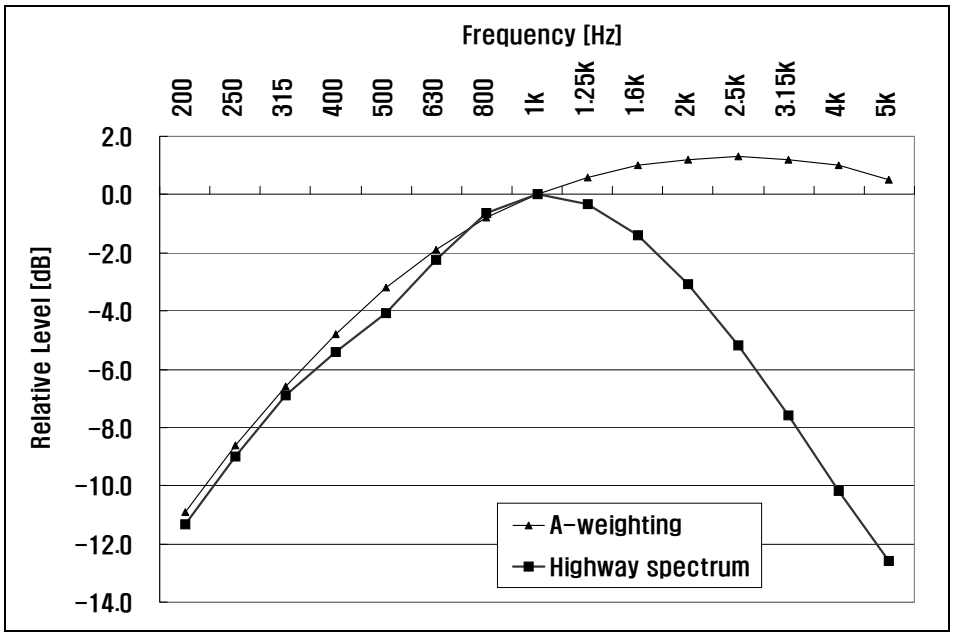


Figure 7. Highway noise spectrum for frequency weighting on acoustic performance estimation

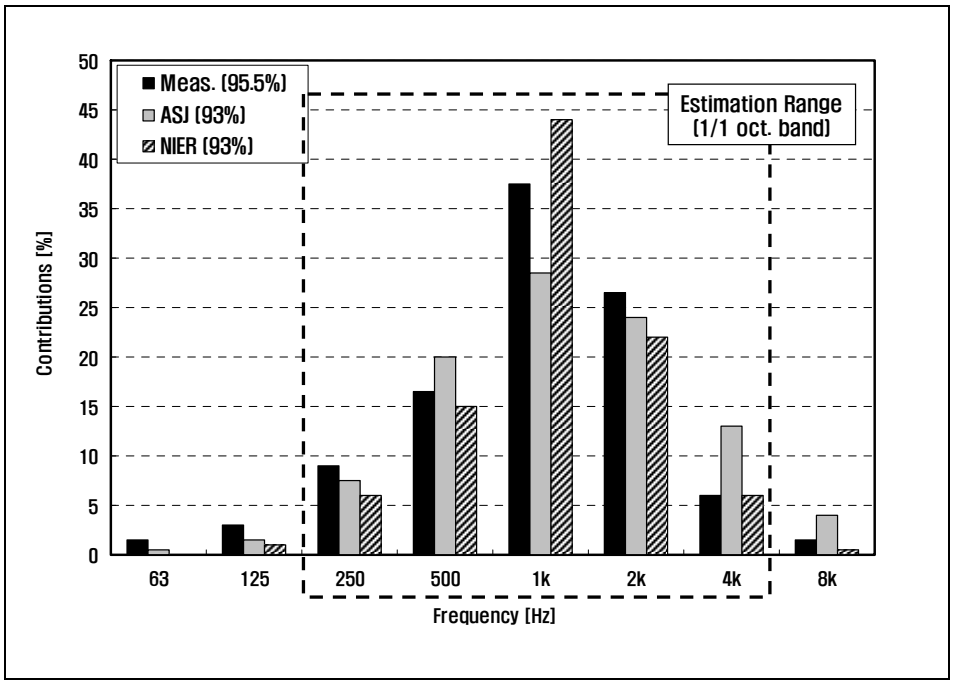


Figure 8. Energy distributions of road traffic noise in frequency spectra

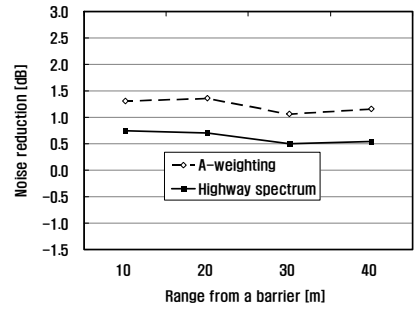
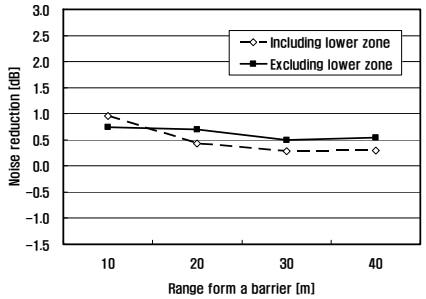
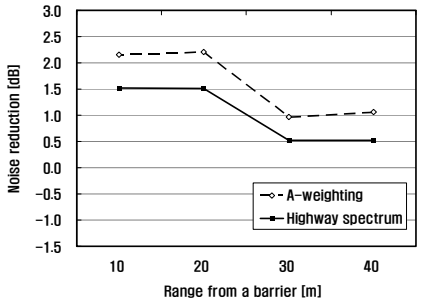
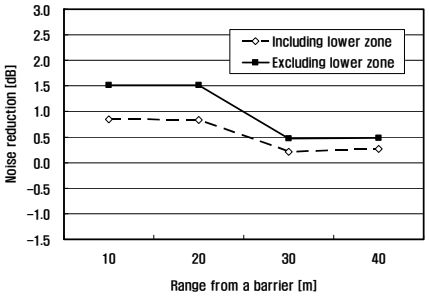
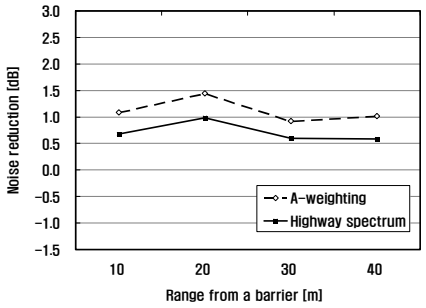
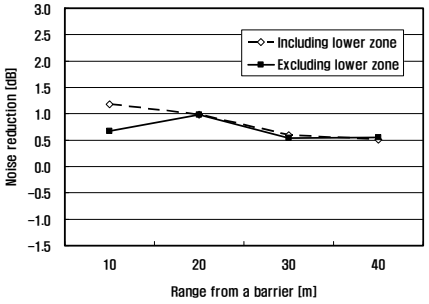
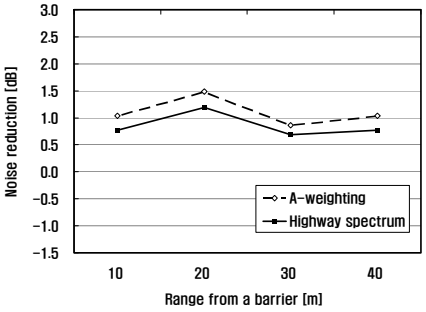
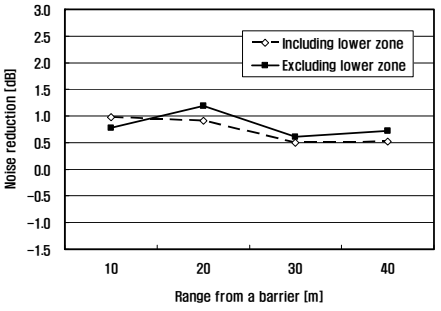
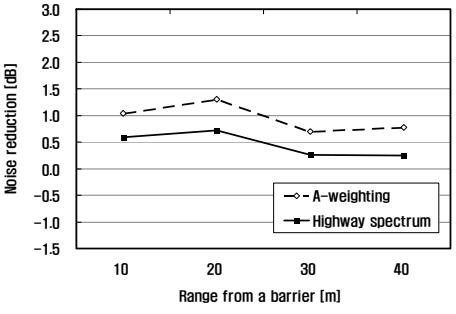
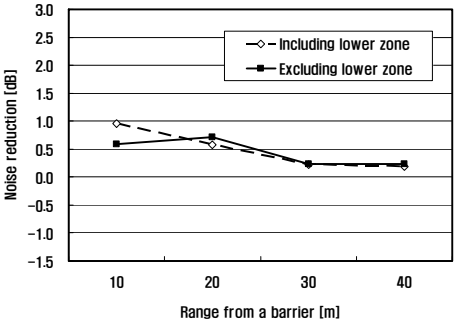
Sample	Considerations for the measuring range from a barrier	Considerations for the measuring range above the ground
A		
B		
C		
D		
E		

Figure 9. Consideration for measuring range from a barrier, above the ground

Figure 9 shows the results of considerations for measuring range from a barrier, above the ground. Because there was no basic theory that NRD's are effective above the line of sight, the measuring range is considered just under the line of sight. Five samples of NRD are considered in the study and from the results shown in Figure 9, the measuring range would be included at least 30 meters from a barrier and another results show in the case of including 30 meters or more in measuring range there no evident difference between including and excluding lower zone, below the reference level. So the measuring range could be decided as (1) Under the line of sight, (2) At least 30 meters from a barrier, (3) Above the reference level. Finally from the results, estimation with highway spectrum weighting is more severe than estimation with A-weighting spectrum and A-weighting spectrum may not be suitable for estimating NRD's against highway noise.

4. SUGGESTION OF NEW METHOD

For a practical test method to estimate the acoustic performance of NRD's, measuring area and weighting frequency spectrum were considered. Figure 10. shows the measuring area for considering. Let the measuring points put from 10 meters to 40 meters behind the barrier, 3 meters below and 6 meters above the reference level. The reference level was located on the top of diffraction edge with and without NRD's. Figure 7 and 8 show the frequency range and weighting spectrum for estimating the NRD's acoustic performance. Figure 11 shows photos of the test facilities suggested on this study.

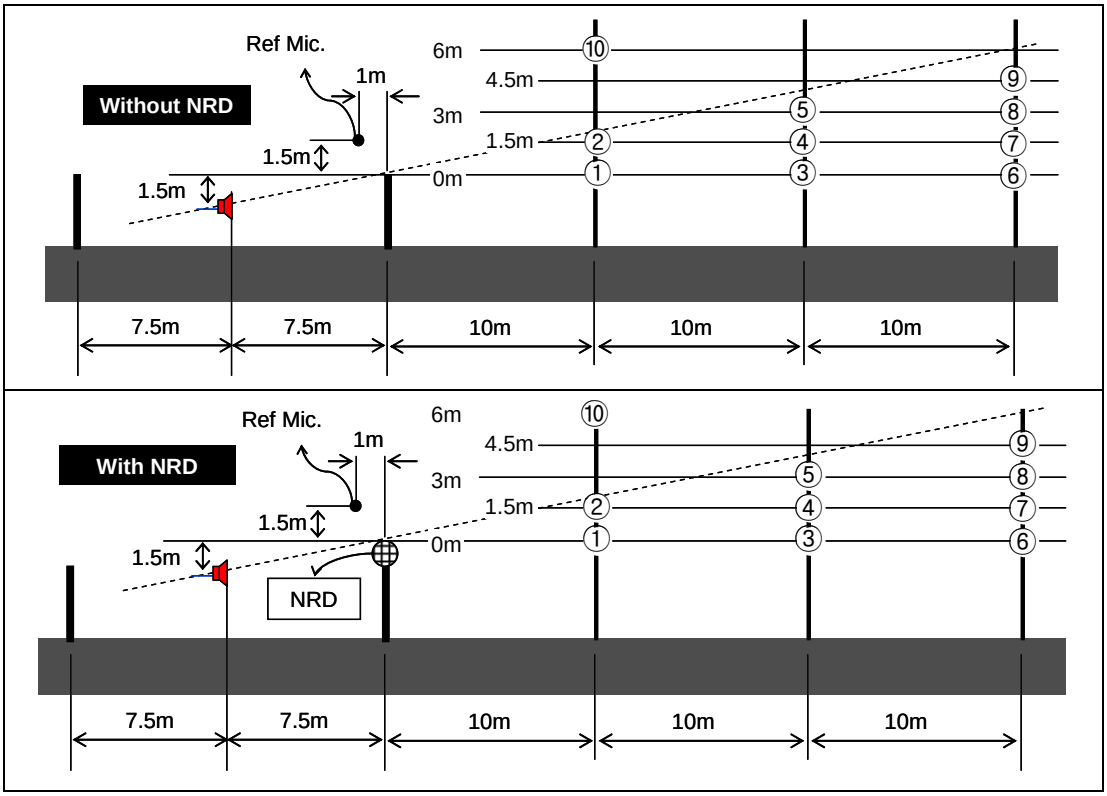


Figure 10. Examples of test results by measuring ranges below the line of sight

Figure 11. Photos of test facilities arranged from suggested method on the study

The ground of source side (left hand) covered with gravels for hard surface and the ground of receiver (right hand) covered with grasses for porous surface referred on ISO 9613-1. The main purpose of new test method is estimate the NRD's in a practical situation. For this purpose the three subjections are suggested as follows.

(1) The receiving area is involved 30 meters behind a barrier at least
(2) The real highway noise frequency spectrum of Korea was used as weighting frequency spectrum
(3) The frequency range for evaluation as a overall level is 250 to 4kHz on octave band center frequency (or 200 to 5kHz on 1/3 octave band center frequency).

5. SUMMARY

A test and estimation method of NRD's acoustic performance was considered for the practical use on the Korea highway road side. By the results, measuring range behind barrier and below the line of sight should be 30 meters at least, and getting near to the barrier the performance of NRD's could be better than far from the barrier in a diffraction area. In the weighting frequency spectrum, the results by A-weighting were better than the results by highway spectrum weighting. This results seem that the highway spectrum weighting is more practical than A-weighting for estimating the acoustic performance of NRD's.

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